UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2007/2008

April 2008

IEK 203 – REKABENTUK PERALATAN PENGOLAHAN AIR
[WATER TREATMENT PLANT DESIGN]

Masa: 3 jam
[Duration: 3 hours]

Sila pastikan bahawa kertas peperiksaan in mengandungi LIMA muka surat yang bercetak sebelum anda memulakan peperiksaan ini.

Jawab EMPAT soalan. Semua soalan boleh dijawab dalam Bahasa Malaysia ATAU Bahasa Inggeris.

[Please check that the examination paper consists of FIVE pages of printed material before you begin this examination.

Answer FOUR questions. All questions can be answered either in Bahasa Malaysia OR English.]

1. Satu unit "rapid-mix" perlu direka untuk air mentah sebanyak 50,000-m^3/hari. Dengan menggunakan masa retensi selama 30s, tentukan saiz tangki V dan kuasa motor pengkacau R_i tersebut. Anggap keefisienan aci-enjin h dan motor M adalah 75% dan 90% masing masing serta suhu air adalah 20°C.

   Diberi:

$$G = \sqrt{\frac{P_f}{\mu \forall}}$$

   $\mu = 10(10^{-4})$ kg/ms

   $R_i = R_f / h M$

   $G = 800\ s^{-1}$

   One hp = 745.7 Watts

   (100 markah)

2. Sebanyak 50 mg/L alum ditambahkan kepada air mentah sebanyak 50,000 m^3/hari yang mengandungi 60 mg/L pepejal terampai.

   (a) Dengan menganggap tahap alkali semula jadi adalah mencukupi, berapa kilogram endapan (sludge) dihasilkan setiap hari?

   (b) Dengan menganggap gravity spesifik sludge adalah 1.04, berapakah isipadu (m^3) endapan (sludge) yang dihasilkan sehari? Anggap bahawa keefisienan penyingkiran basin mengendap adalah 65%

   $Al_2(SO_4)_3.\ 14.3\ H_2O + 3Ca(HCO_3)_2 \rightarrow 2Al(OH)_3 + 3CaSO_4 + 14.3\ H_2O + 6CO_2$

   Al=26.98, S=32.1, H=1.0, O=16, C=12, Ca=40

   Ketumpatan air ρ=1000kg/m^3.

   (100 markah)

3. Masa pemendapan (retensi) bagi satu tangki prototaip dan kadar limpah ialah 44 min dan 0.10m/min masing-masing. Rancangkan suatu tangki pengendap segiempat tepat dengan menggunakan nilai-nilai yang diberi untuk kadar aliran sebanyak 20 000 m^3/hari.

Diberi:

$$Z_0 = \upsilon_0 t_0 \qquad \frac{Z_0}{\upsilon_0} = \frac{W Z_0 L}{Q}$$

u_h=halaju mendatar =0.8m/h

(100 markah)

4. Air mentah yang perlu dirawat melalui proses lime-soda untuk mengurangkan kekerasannya mempunyai sifat-sifat berikut: CO_2=22.0mg/l, Ca^{2+}=80mg/L, Mg^{2+}=12.0mg/L, Na^{+}= 46.0mg/l, HCO_3^{-} = 152.5 mg/L and SO_4^{2-}=216.0mg/L.

(a) Tentukan sama ada nombor imbangan ion positif dan negative adalah seimbang.

(b) Bagi kadar 25, 000 m^3/hari, kirakan keperluan kimia dan berat pepejal serta isipadu endapan (sludge) yang dihasilkan.

Anggap bahawa kapur yang digunakan adalah 90% tulen dan soda ash yang digunakan adalah 85% tulen. Anggap graviti spesifik endapan (sludge) adalah 1.04

C=12, O=16, Ca=40, Mg=24, Na=23, H=1.0, S=32.

For CO_2: CO2 + CaO + H2O → $CaCO_3 + H_2O$

For $Mg(HCO_3)_2$: $Mg(HCO_3)_2 + 2CaO + 2H_2O \rightarrow Mg(OH)_2 + 2CaCO_3 + 2H_2O$

For $Ca(HCO_3)_2$: $Ca(HCO_3)_2$ + CaO + H2O → $2CaCO_3 + H_2O$

For $CaSO_4$: $CaSO_4 + Na_2CO_3 \rightarrow$ CaCO3 + Na_2SO_4

(100 markah)

5. Suatu sampel air yang mengandungi 0.4 mEq/L $CaCO_3$ perlu distabilkan dengan menggunakan H_2SO_4 atau CO_2. Berapakah kepekatan $CaCO_3$ dalam mg/L?

$2CaCO_3 + H_2SO_4 \rightarrow Ca(HCO_3)_2 + CaSO_4$

$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

(100 markah)

1. *A rapid-mix unit is to be designed for 50,000-m^3 /day raw water. Using a detention time of 30s, determine the size of the tank V and the motor horsepower of the mixer R_i, assuming a shaft h and a motor efficiency M of 75% and 90%, respectively. Assume a water temperature of 20 °C.*

   Given:

$$G = \sqrt{\frac{P_f}{\mu \forall}}$$

   $\mu = 10(10^{-4})$ *kg/ms*

   $R_i = R_f /\ h\ M$

   $G = 800\ s^{-1}$

   One hp = 745.7 Watts

   (100 marks)

2. *A 50 mg/L alum is added to 50,000 m^3/day of raw water containing 60 mg/L of suspended solids.*

   (a) Assuming that sufficient natural alkalinity is present, how many kilograms of sludge are produced per day?

   (b) Assuming that the specific gravity of the sludge is 1.04, how many cubic meters of the sludge are produced per day? Assume that removal efficiency of the settling basin is 65%.

   $Al_2(SO_4)_3.\ 14.3\ H_2O + 3Ca(HCO_3)_2 \rightarrow 2Al(OH)_3 + 3CaSO_4 + 14.3\ H_2O + 6CO_2$

   Al=26.98, S=32.1, H=1.0, O=16, C=12, Ca=40

   Density of water $\rho = 1000 kg/m^3$.

   (100 marks)

3. *The prototype detention time and overflow rate of a settling basin were calculated to be 44 min and 0.10m/min respectively. Design a rectangular settling basin using these values for a flow rate of 20 000 m^3/d.*

Given:

$$Z_0 = \upsilon_0 t_0 \qquad \frac{Z_0}{\upsilon_0} = \frac{W Z_0 L}{Q}$$

u_h=*horizontal velocity=0.8m/h*

(100 marks)

4. *A raw water to be treated by the lime-soda process to the minimum hardness possible has the following characteristics:* CO_2*=22.0mg/l,* Ca^{2+}*=80mg/L,* Mg^{2+}*=12.0mg/L,* Na^{+}*= 46.0mg/l,* HCO_3^- *= 152.5 mg/L and* SO_4^{2-}*=216.0mg/L.*

   (a) Check if the numbers of equivalents of positive and negative ions are balanced.

   (b) For a flow of 25, 000 m^3/day, calculate the chemical requirements and the mass solids and the volume of sludge produced.
   Assume that the lime used is 90% pure and the soda ash used is 85% pure.
   Also, assume that the specific gravity of the sludge is 1.04.

C=12, O=16, Ca=40, Mg=24, Na=23, H=1.0, S=32.

For CO_2: $CO2 + CaO + H2O \rightarrow CaCO_3 + H_2O$

For $Mg(HCO_3)_2$: $Mg(HCO_3)_2 + 2CaO + 2H_2O \rightarrow Mg(OH)_2 + 2CaCO_3 + 2H_2O$

For $Ca(HCO_3)_2$: $Ca(HCO_3)_2 + CaO + H2O \rightarrow 2CaCO_3 + H_2O$

For $CaSO_4$: $CaSO_4 + Na_2CO_3 \rightarrow CaCO3 + Na_2SO_4$

(100 marks)

5. *A sample of finished water containing 0.4 mEq/L of* $CaCO_3$ *is to be stabilized using* H_2SO_4 *or* CO_2*. What is the concentration of* $CaCO_3$ *in mg/L?*

$2CaCO_3 + H_2SO_4 \rightarrow Ca(HCO_3)_2 + CaSO_4$

$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

(100 marks)

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